REMARKS

The rejection of claims 1 to 17 as being obvious over Qvintus et al (WO 97/10379) is traversed.

Claim 1 has been amended to clarify that the dilution factor is for all washing liquids added to the washing device, that the "first washing liquid" is exclusively, (see term "consisting of"), the "washing liquid filtrate" and that the "second washing liquid" includes all washing liquids introduced from outside of the washing device, wherein the washing liquids are introduced to the washing device separately from the pulp. Claim 1, as amended, requires the second washing liquid to be the wash liquid introduced from outside the washing device.

In the washing device, a first washing liquid consists of circulated filtrate from the washing device in an amount of 1.5 - 3.5 t/adt pulp. The pulp is also washed with a second washing liquid which consists of wash liquid introduced from outside of the washing device. The dilution factor (DF) in the second washing liquid is less than 1 t/adt and the total DF in the washing device is more than 0 t/adt.[1] The dilution factor in the second washing liquid can be (and preferably is) below zero.

The dilution factor is defined in the application as the difference between the used wash liquid (e.g., fresh wash liquid) and the liquid exiting the washer. [Apln., page 3, the paragraph beginning at line 24]. A similar definition of dilution factor (D) is also given

[1] The dilution factor (DF), or washing water surplus, is explained on page 3, lines 24 - 31, and page 4, line 34 to page 5, line 8 of the application.

in Exhibit A, which is Gullichsen, PAPERMAKING SCIENCE AND TECHNOLOGY, Book 6A "Chemical Pulping" at pp. 314-315 (1999).

In rejecting the claims, the Examiner asks whether "Applicant is stating that the fresh water of Qvintus remains constant or has too great of a dilution factor to read on the claim, or if Applicant is arguing that the total water loss as having too much of a dilution." Office Action at page 3, lines 1 to 3. Applicant does not argue that the patentability of its invention turns on whether the fresh water added to Qvintus remains constant or that the total water loss in Qvintus results in too much dilution.

Qvintus suggests that the washing results can be improved by using the internal circulation of filtrate. Qvintus also teaches in agreement with conventional prior art, that it is not possible to reach a satisfactory washing result between bleaching stages without an adequate amount of fresh water introduced from the outside (see explanation on page 5, lines 26 - 30 of the present application). In view of Qvintus, those of ordinary skill in the art would expect that the washing result is deteriorated if the internal circulation is increased and the use of fresh water is decreased. A person of ordinary skill in the art would not have found obvious the present invention based on a reading of Qvintus.

Qvintus teaches that a satisfactory washing result between bleaching stages requires a large amount of fresh water (second washing liquid) introduced from the outside (See page 5, lines 26 - 34 of the present application). Qvintus teaches that the amount of fresh washing water added to the washing device is not to be decreased

1646515

because filtrate water is recirculated. Qvintus discloses using internal circulation of filtrate in the washing device to increase the total amount of the washing liquid used in the washing device. The internal circulation of filtrate does not change the dilution factor in Qvintus.

Qvintus discloses a high amount fresh wash liquid as indicated by Figures 6 and 12 to 14 of Qvintus. These figures show fresh water being introduced at a rate of 7.6t/adt and liquid in the washed pulp is discharged at a rate of 5.1 t/adt, such that the dilution factor is 2.5 t/adt for Qvintus. The low amount of second washing liquid (fresh water) in the claim invention is indicated by the requirement of a dilution factor of less than 1 t/adt for the second washing liquid. Qvintus' dilution factor of 2.5 is substantially greater than the dilution factor of less than 1.0 recited in the claims.

The present inventors determined that the amount of fresh water added to a washing device may be reduced. Balance calculations show that reusing wash water inside one and the same bleaching stage leads to the same washing result as when using only externally-introduced washing liquid, as long as the total dilution factor is the same and the efficiency of the washing device is high enough to ensure an adequate purity of the circulated filtrate fraction. This is a surprising result, as Qvintus and the state of the art prior to the invention teach that without an adequate amount of fresh water introduced from outside it is not possible to reach a satisfactory washing result between bleaching stages. A person of ordinary skill in the art would expect that the washing result is

deteriorated if the internal circulation is increased and the use of fresh water is decreased. The claimed method of washing remarkably decreases the water consumption of bleaching plants without significant additional investments.

The Office Action, at para. 16, states that:

> "[w]ith respect to the values of dilution factor, it is a result effective variable based on the amount of water entered into the drum, the amount of spinning performed, and the desired final consistency, as all taught by Qvintus. All these variables are easily controlled by one ordinary skill in the art..., and it has been held that optimizing result effective variables through routine experimentation is within the ability of one of ordinary skill."

The present method is not based on the control of the variables listed by in the rejection. A novel feature of the present method is that in bleaching the use of water, especially fresh water, coming from outside a wash stage in question, may be decreased, such that the washing is completed under a shortage of washing water. This would result in a poor washing result between bleaching stages, if the internal circulation inside a washing stage would not be practiced. The teaching of Qvintus is contrary to what the present method discloses. That is, e.g., in Figures 12 - 14 of Qvintus, the internal circulation of filtrate is

increased from 1.98 to 3.11 (see the third numerical value from the right in the bottom part of each of the Figures). Yet, the amount of fresh water (WI) is kept constant. This supports the consistent teaching in this art, namely that it is not predictable to reach a satisfactory washing result between bleaching stages without an adequate amount of water introduced from the outside. In Figures 6 and 12 - 14 of Qvintus, the dilution factor in the latter wash is in fact higher than 1 t/adt as presently claimed, namely 7.6 - 5.1 = 2.5 t/adt. As a result, the inventive combination of a low amount of fresh liquid, expressed as a dilution factor of less than 1 t/adt, and an amount of the circulated filtrate of 1.5 - 3.5 t/adt pulp was not obvious to the skilled person at the filing date. In paragraph 7. of the Office Action the Examiner refers to page 11, line 14 of Qvintus. Here it is described that 2,5 tons of liquid is removed from the web and the system, but this is not the amount of the circulated filtrate.

The references included in the PCT Search Report should be considered by the USPTO, if they have not already been considered. In this National Stage application, the USPTO should consider the reference cited in the PCT Search Report. An Information Disclosure Statement (IDS) is being submitted which identifies these references.

All claims are in good condition for allowance. If any small matter remains outstanding, the Examiner is requested to telephone applicants' attorney. Prompt reconsideration and allowance of this application is requested.

The Commissioner is hereby authorized to charge any deficiency, or credit any overpayment, in the fee(s) filed, or asserted to be filed, or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our Account No. 14-1140.

Respectfully submitted,
NIXON & VANDERHYE P.C.

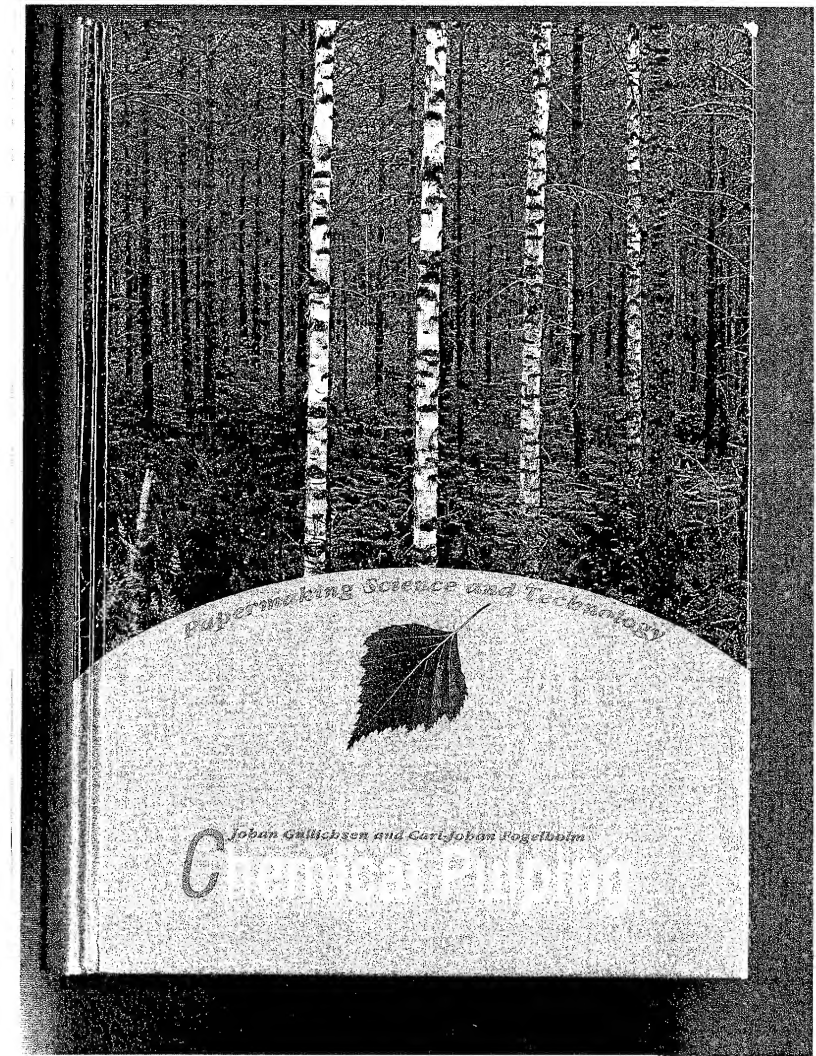
By: /Jeffry Nelson/

Jeffry H. Nelson
Reg. No. 30,481

JHN:glf

901 North Glebe Road, 11th Floor
Arlington, VA 22201-4714
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

EXHIBIT A


Papermaking Science and Technology
Johan Gullichsen and Carl-Johan Fogelholm

Papermaking Science and Technology

a series of 19 books
covering the latest
technology and
future trends

Book 6A

Chemical Pulping

Series editors
Johan Gullichsen, Helsinki University of Technology
Hannu Paulapuro, Helsinki University of Technology

Book editors
Johan Gullichsen, Helsinki University of Technology
Carl-Johan Fogelholm, Helsinki University of Technology

Series reviewer
Brian Attwood, St. Anne's Paper and Paperboard Developments, Ltd.

Book reviewers
Martin MacLeod, PAPRICAN
Desmond Smith, Acrowood
Bill Fuller, Weyerhaeuser
Hongi Tran, Pulp & Paper Centre, University of Toronto
Norman Duke, Avenor

Published in cooperation with the Finnish Paper Engineers' Association and TAPPI

ISBN 952-5216-00-4 (the series)
ISBN 952-5216-06-3 (book 6)

Published by Fapet Oy
(Fapet Oy, PO BOX 146, FIN-00171 HELSINKI, FINLAND)

Printed by Gummerus Printing, Jyväskylä, Finland 2000

Printed on LumiMatt 100 g/m², Stora Enso Fine Paper, Imatra Mill

Certain figures in this publication have been reprinted by permission of TAPPI.

with a press roll. In this case, the fiber mat travels through a press nip formed between the filter media and the press roll. The press roll may also have perforations and hollow sections to help dewatering in two directions.

Design and hydrodynamic functions of all filtration, displacement, and pressing machines are composed of the simple unit operations of Fig. 37. They can be treated separately. Figure 39 depicts the fluid mechanical model for thickening and displacement operations.

Filtration

Filtration is a dynamic process where the accumulation of a fiber mat on a filtering media depends on time and rate. Regrouping Eqs. 28, 29, and 31 at any given pressure gradient and time provides a calculation for the equilibrium consistency profile:

$$\frac{\partial \varepsilon_s}{\partial t} = \frac{\partial \varepsilon_s \left(\frac{k \partial p_s \partial \varepsilon_s}{\mu \partial \varepsilon_s \partial z} \right)}{\partial z} + v_m \frac{\partial \varepsilon_s}{\partial z} \tag{46}$$

where t is time
- z distance from the filtering media
- k permeability (Eq. 27)
- v_m the permeating velocity
- ε_s the solids factor that is equal to $1 - \varepsilon$ in Eq. 28.

Fiber concentration at the face of the fiber mat is equal to the feed consistency. Equation 29 gives zero consistency at zero compacting pressure. The inlet consistency is expressed by introducing a fictive compacting pressure, p_A, that is equal to $(C_0/M)^{1/N}$ according to Eq. 29.

The concentration of the filtrate from filtration or thickening is equal to that of the free liquid in the suspension.

Displacement

Liquid displaced through a fiber mat flows in the free flow channels only. Enclosed liquid volumes do not participate in the flow. Equation 46 provides an estimate of the consistency profile and fluid drag calculations for displacement operations.

Ideal displacement can never occur due to the heterogeneous nature of the bed material. Flow will be faster in some sections than in other sections. Consistency gradients caused by fluid drag will result in a significant flow acceleration in free flow channels as liquid flows toward the filtering media as Fig. 38 shows. Local flow breakthrough or "fingering" may occur if the viscosity of the displacing liquid is considerably lower than

the viscosity of the displaced liquid. This is also possible if mat thickness or displacement consistency is too low.

Figure 39 shows an example of how flow directional dispersion influences the front of a liquid flowing through a pulp mat. Figure 40 depicts the relative filtrate concentration vs. filtration time or mat length. Description of this flow-related pattern uses a common advection-dispersion equation:

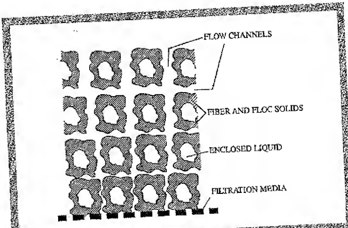


Figure 38. Schematic display of free flow channels in a fiber bed under fluid stress.

$$\frac{\partial c}{\partial t} = D_L \frac{\partial^2 u}{\partial z^2} - v\frac{\partial c}{\partial z} \tag{47}$$

where t is time
z the distance from the point of introduction of displacing liquid
v interficial velocity
$c = c(z,t)$ is the solute concentration in the liquid phase
D_L the hydrodynamic dispersion coefficient, a measure of deviation from the ideal plug step response.

Sherman found that the D_L/v ratio was constant for a given bed of particles. Only the bed thickness, L, influences the value of the Peclet-number, $Pe = vL/D_L$. Brenner[20] presents solutions of Eq. 47 with boundary and initial conditions for several Peclet-numbers. These models describe the physical flow phenomena in

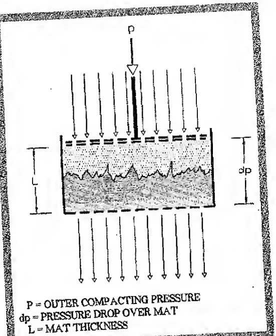


Figure 39. General flow model for flow through a fiber mat.

the flow channels of a fiber bed without consideration of physico-chemical sorption and diffusion phenomena. They further assume that the bed material is homogeneous.

Norden[21] has developed a "black box" process model to describe flow directional dispersion using leaching theory. The material balance of a displacement operation is described with a single process parameter that describes the efficiency of the machine. The Norden model derives the step response from an equivalent number of ideal mixing stages coupled in cascade. The resulting number is efficiency, E:

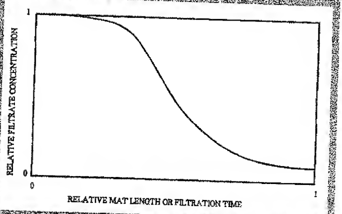


Figure 40. Step response curve of relative filtrate concentration caused by flow directional dispersion.

$$E = \frac{ln\dfrac{L_0(x_0 - y_1)}{L_1(x_1 - y_2)}}{ln\dfrac{V_2}{L_1}} \tag{48}$$

$$E = \frac{L_1(y_1 - y_2)}{L_0(x_0 - y_1)} \quad , v_2 = L_1 \tag{49}$$

where L_0 and L_1 are flow rates of liquid with incoming and departing pulp slurry, respectively
V_2 and V_1 the displacing and displaced liquid flow rates
x_0 and x_1 the weight fractions of solute in L_0 and L_1, respectively
y_2 and y_1 the weight fractions in V_2 and V_1.

In this equation, $E = \infty$ corresponds to plug flow, and E =1 means ideal mixing. The value of E is constant for a given fiber bed without considering diffusion and sorption phenomena. Diffusion and sorption effects may influence the outcome when calculating with real process measurements. Description of the step response curve of Figure 40 can use an E-value or a Peclet-number.

2.4.1 Displacement efficiency in washing

All washing processes use the same principles. These are combinations of dilution, thickening, and displacement. The following definitions have common use to define a washing process using the notations of Fig. 58:

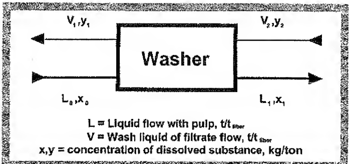


Figure 58. Schematic washing stage.

- Wash ratio, $W = V_1/L_0$ (89)
- Weight ratio, $R = V_2/L_1$ (90)
- Dilution factor, $DF = V_1 - L_0$ or $V_2 - L_1$ (91)
- Displacement ratio, $DR = (x_0 - x_1)/(x_0 - y_2)$ (92)

Washing efficiency as defined in Equations 48 and 49 is as follows:

$$E = \frac{ln\frac{L_0(x_0 - y_1)}{L_1(x_1 - y_2)}}{ln\frac{V_2}{L_1}} \quad , \; V_2 \neq L_1 \qquad (93)$$

$$E = \frac{L_1(y_1 - y_2)}{L_0(x_0 - y_1)} \quad , \; V_2 = L_1 \qquad (94)$$

Washing yield according to mass balance is the following:

$$Y = \frac{V_1 y_1 - V_2 y_2}{L_0 x_0} \times 100 = (\,)\% \qquad (95)$$

Most washing processes are multistage countercurrent operations as Fig. 59 shows. The total efficiency of a chain of washers is the following:

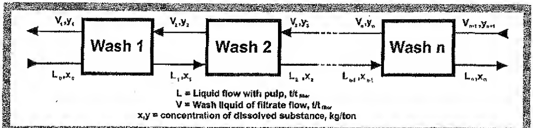


Figure 59. Schematic multi-stage washing system.

$$E \ln R = E_1 \ln R_1 + E_2 \ln R_2 + \dots\dots\dots\dots + E_n \ln R_n \qquad V_2 \neq dL_1 \tag{96}$$

or

$$E/L = E_1/L_1 + E_2/L_2 + \dots\dots\dots + E_n/L_n \qquad V_2 = L_1 \tag{97}$$

or

$$E = E_1 + E_2 + \dots\dots\dots + E_n \quad , L = L_1 = L_2 = \dots\dots = L_n \tag{98}$$

The washing yield of a washer with known E-value is as follows:

$$Y = 1 - \frac{W-1}{WR^E - 1} \qquad R \neq 1 \neq W \tag{99}$$

$$Y = 1 - \frac{1}{L_0 \frac{E}{L_n} + 1} \qquad R = W = 1 \tag{100}$$

$$Y = 1 - \frac{1}{E+1} \qquad L_0 = L_N \tag{101}$$

Figure 60 shows the development of washing yield as a function of weight ratio. This demonstrates the strength of the E-value concept. Displacement ratio, DR, gives only one point in the diagram, but E-value is constant for all W-values.

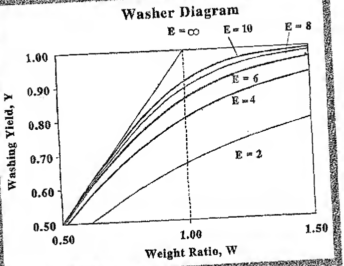


Figure 60. Washing yield vs. liquid weight ratio at different E-values.

Corresponding equations for multistage operations are then as follows:

$$Y = 1 - \frac{W - 1}{WR_1^{E_1}R_2^{E_2}\ldots\ldots R_n^{E_n} - 1} \qquad R \neq 1 \neq W \tag{102}$$

or

$$Y = \frac{1}{L_0\left[\frac{E_1}{L_1} + \frac{E_2}{L_2} + \ldots\ldots + \frac{E_n}{L_n}\right] - 1} \qquad R \neq 1 \neq W \tag{103}$$

The efficiency of a washer displacement zone is not always independent of hydraulic loading. It may decline as a function of wash ratio, W. Gullichsen *et al.*[43] developed a correction factor using measurements from many washers:

$$E = E_k \frac{1 - \frac{1}{W}}{\ln W} \tag{104}$$

where E is the weight ratio corrected efficiency
E_k measured E-value at $W = 1$
W the wash ratio.

Strictly speaking, the E-value is only valid for displacement operations and includes both sorption and diffusion phenomena if calculated directly from field sample analysis. The data may reflect the flow behavior in displacement if concentrations of contaminants are sufficiently high to override the impact of sorption diffusion phenomena. The situation is much different in the final stages of washing. Here diffusion and sorption may become dominant.

2.4.2 Diffusion and sorption phenomena in washing

E-values as defined here reflect only the fluid mechanical aspects of washing. Eqs. 89–104 assume that mass transfer from the enclosed liquid volume and liquid in the fiber wall to the free liquid is instantaneous. This is not the case when sorption and diffusion occur. To maintain the physical meaning of the E-model, one must change the definition of the concentration, x, to relate to the free liquid only, x_f.

Diffusion involves a transfer rate, i.e., the proximity to equilibrium is time dependent. The material balance for substance transfer from the fiber and its enclosed liquid volume into the flowing liquid becomes the following:

$$V\partial y = L\partial x \tag{105}$$